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University of Hawaii at Manoa

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What Makes a Good Avocado Cultivar Good?

Many people have a favorite avocado, perhaps the one that grew in their backyard when they were growing up. What makes one person consider an avocado "good" may be largely a matter of personal taste. But when horticulturists choose among seedlings and select one for plant propagators to increase and farmers to cultivate, many factors are involved. This publication is about the factors considered when selecting avocado cultivars.

Avocado (*Persea americana*) cultivars are selected and named because of particularly desirable fruit and tree characteristics. Every avocado tree grown from seed is a potential candidate for selection as a cultivar, because cross-pollination in avocado's reproduction process ensures genetic variability. Once selected, cultivars are propagated by vegetative methods, such as grafting, to produce genetically identical trees.

The following sections describe characteristics considered in evaluating avocados and some of the factors affecting the expression of those characteristics. This information may help home gardeners and commercial growers to distinguish and select for desirable characteristics in avocodo cultivars for their situations. At least, it can provide the reader with increased knowledge of horticultural evaluation methods and greater appreciation of the genetic diversity present in avocado.

The expression of an avocado cultivar's genetic characters varies with environmental influences associated with climate and seasonal variation in temperature, relative humidity, and rainfall. Avocado characters affected by climate include disease resistance, yield, bearing habit, fruit size and quality, and season of maturity. Therefore, a cultivar that is productive or has good fruit elsewhere in the world may not be adapted to growing in Hawaii, and one that does well in Hawaii at 1500 ft elevation may do poorly at 100 ft.

Hawaii has many different soil types and micro-climates, and these may change over short distances. For this reason, it is difficult to recommend "the best" avocado cultivars for specific locations unless experience is available for that (or a very similar) location. Lacking prior experience, an experimental approach is called for in selecting an avocado cultivar that is well adapted for a given location.

Avocado selection in Hawaii

Avocados were introduced to Hawaii in the early 19th century, probably by the Spanish horticulturist Don Francisco de Paula Marin. A formal program of avocado selection began in Hawaii with the initiation of the Hawaii Agricultural Experiment Station (HAES) in 1901. University of Hawaii horticulturists have imported cultivars for evaluation, established seedling selection plantings, and held contests to search for desirable avocado seedlings. UH Department of Horticulture evaluations have been conducted at many of the HAES research stations, in particular those at Kainaliu (Kona) and Malama Ki (lower Puna) on the Big Island and Poamoho (above Waialua) on Oahu.

Avocado evaluation programs should be conducted in the particular climatic niche in which the crop is intended to be grown. When this is not feasible, programs concentrate first on observing seedlings of promising maternal parents and selecting those with superior characteristics at one site. Then, the selections are clonally propagated and evaluated for their performance at other locations.

This second stage—evaluating clonally propagated trees—is important in assessing tree size and shape, because seedling trees tend to be larger and more vigorous and begin bearing later than grafted trees. To evaluate cultivars for commercial production, their development and yield should be observed over a 3–4-year period after initiation of bearing. For fruit quality evaluations, observations should be taken on 30 or more fruits from several years' harvests.

Cultivars, varieties, and races

The horticultural term "cultivar" (cultivated variety) refers to recognized clonal varieties reproduced asexually by vegetative propagation methods, such as grafting. In a general sense, each seedling avocado is a variety. In its strict botanical meaning, the term "variety" does not apply to avocados, because botanists do not recognize subcategories of *Persea americana*. Horticulturists, however, recognize three "races" of avocado, the Guatemalan, Mexican, and West Indian races (Table 1). Many—if not most—modern avocado cultivars are complex hybrids of two or all of these races, resulting from cross-pollination. Hybrids have characteristics that generally are intermediate between those of the parent races. Most avocado cultivars grown in Hawaii are hybrids of the Guatemalan and West Indian races, but a few pure Guatemalan race cultivars are also grown. The popular commercial cultivar 'Sharwil' is considered to be a Guatemalan-Mexican hybrid.

Avocado flowering

Avocados have a special flowering behavior that under most conditions ensures cross-pollination between trees of the two avocado flowering types, known as Type A and Type B. Every avocado tree is one type or the other. The avocado flower is called a "perfect" flower because it has both a female part (the pistil, containing the ovary) and a male part (the stamens, bearing the pollen). Although self-pollination occasionally occurs, an avocado flower is not likely to self-pollinate because the different parts (male and female) function at different times. When the female part of a flower is ready to receive pollen, the male part of that flower is not ready to shed pollen, so the pollen available at the time the female part is receptive is likely from a different tree, of the contrasting flowering type, carried by an insect.

The practical importance of this difference in flowering type is that for adequate pollination and good yields, trees of both types should be near enough to each other to be within the range of pollinating insects. Lack of the other flowering type as a pollinator is seldom a problem in residential areas, where several avocado trees are usually present in the vicinity. When planning avocado orchards or planting in areas isolated from other avocado trees, cultivars of both flowering types should be used.

Disease "resistance" in avocado

Avocados are highly susceptible to root rot caused by *Phytopthora cinnamomi* in the soil. This fungus disease develops when soils are temporarily waterlogged or even kept moist for long periods by excessive rainfall or irrigation. Once infected, the trees either die or their growth is inhibited. Avocado should not be planted on soils that are subject to flooding or have poor drainage. Susceptibility to phytophthora root rot is the reason why many of the commercial plantings of avocado attempted in Hawaii have been in the sloping, rocky, well drained soils of the Kona region of the Big Island.

Presence of avocado trees in high-rainfall areas may not mean that they have resistance to phytophthora root rot; there may be low levels of the fungus in the particular location, or the tree may have avoided a lethal infection by somehow maintaining a partially healthy root system.

Table 1. General characteristics of avocado races.

Race	Origin	Leaves	Fruit maturity	Fruit size	Fruit skin
Guatemalan	Guatemalan highlands	unscented	winter–spring	M–L (>150 g)	hard, tough, thick, pebbled
Mexican	Mexican highlands	anise-scented when crushed	summer–fall	S (<150 g)	thin, smooth
West Indian	South American and Mexican lowlands below 1000 ft	unscented	late summer–fall	M–L (>150 g)	smooth, thin, pliable

Certain clonally propagated avocado rootstocks have been developed in California and elsewhere that are believed to have some degree of resistance to phytophthora root rot. Such resistance has not been verified in Hawaii, and observations in CTAHR plantings of avocado trees grown on supposedly resistant rootstocks have not borne out the claims.

While there may not be much hope for selecting for resistance to the various diseases to which avocado is susceptible, there is certainly opportunity to select *against* disease susceptibility by removing unhealthy or disease-prone plants and trying alternative cultivars. Starting out with disease-free scion stock grafted onto vigorous, healthy rootstocks grown in sterile media is the first step to ensure good growth of avocados (there is presently no system in Hawaii to certify disease-free avocado plant stock). Other ways to help avoid incidence of phytophthora root rot include selecting suitable planting locations, avoiding excessive irrigation, maintaining field sanitation by not transporting or tracking in soil from other areas, and emphasizing soil organic matter in the soil fertility management program.

Cultivar selection criteria

Important criteria in selecting avocado cultivars can be grouped into (1) production and (2) fruit quality considerations. For home gardens, production characteristics may not be as important as good fruit quality. For commercial growers, production characteristics may be very important, but consumer preferences for fruit appearance and quality are also important in determining whether or not a selection is appropriate.

Production considerations. From the commercial grower's point of view, a desirable cultivar is high yielding, begins to bear at an early age, is easy to harvest, and has fruit that can be "stored" on the tree and harvested over a relatively long period of time. Large, vigorously growing trees may be difficult to harvest because of their height and may quickly crowd the orchard. Fruits should not become soft-ripe on the tree soon after maturity. They should remain on the tree for as long as possible after maturing before ripening or falling, in order to spread harvesting over a longer period. Fruits should ripen evenly and predictably, with a minimum of disease damage. Seeds must not be loose in the seed cavity, because internal bruising caused by winds or during handling and shipping operations will result in postharvest losses. Disease and insect pest resistance and soil tolerances can be important in some locations. Some characteristics of desirable avocado cultivars recommended for Hawaii are listed in Table 2.

Fruit considerations. Consumer preferences involve fruit appearance and quality. Table 3 gives fruit characteristics of recommended cultivars. University of Hawaii horticulturists have rated factors such as flesh texture, seed size, general appearance, flavor, and ease of peeling on a scale of 1 to 4 points, where 2 or less is unacceptable, 2.5 is mediocre, 3 is good, 3.5 is very good, and 4 is excellent. For a commercial cultivar, a score below 3 in any category is reason enough to reject the candidate. A large number of avocado cultivars have been evaluated by the UH Department of Horticulture, and many of them are listed in Table 4.

It cannot be overemphasized that environmental fac-

Table 1 (continued)

Mature skin appearance	Fruit oil content	Seed size	Seed looseness	Flesh quality	Storage quality	Adaptation in Hawaii
no bloom	med-high (15–30%)	S–M	tight	(not well defined)	good on tree or refrigerated	> 800 ft elev., cool
dull from bloom, shiny when wiped	med-high (10–25%)	L	often loose in cavity	strong flavored, may be fibrous	not good on tree or refrigerated	800–2000 ft elevation
shiny, little bloom	low–med (5–14%)	L	sometimes loose in cavity	mild flavored	not good on tree or refrigerated	< 800 ft elev.

tors strongly influence the production and fruit quality characteristics of avocado cultivars. Season of maturity varies considerably with elevation. 'Itzamna' grown in Kona at 1200 ft elevation was observed to mature in April and to have dropped its fruits by the end of July, whereas at 2000 ft the fruit began to mature in August and fruits remained on the trees through December. This also supports the general observation that avocados grown at higher elevations often have longer harvesting periods.

Temperature, humidity, and rainfall characteristics of different elevations interact to influence the variability observed in avocado cultivars. 'Frowe' produced fruit with adequate oil content at low elevations, but at 1600 ft elevation in Kona it produced undesirable, watery fruit. Similarly, 'Case' has been observed to have low oil content when grown at 2000 ft elevation in Kona. Thus, some cultivars that are not suitable for upper Kona or mauka areas of Maui can be satisfactory elsewhere under drier or warmer climatic conditions.

The foregoing should explain why avocado cultivars that are well known in other parts of the world are not necessarily desirable for growing in Hawaii. Inexpensive grafted avocado plants have been imported from California and sold in local garden shops, but consumers shopping for an avocado plant should beware of these. California cultivars seldom perform well in Hawaii, even the famous 'Hass', which when grown in Hawaii characteristically has fruit about half the size and a seed twice as large as when grown in California.

Taste factors and oil content

It is difficult to categorize avocado flavor. The word "nutty" comes close to describing it, and a scale ranging from "mild" to "rich" (or "watery avocado flavor" to "strong avocado flavor") can be used to rate its intensity. Some avocados are considered "sweet." Undesirable, negative factors include bland flavor, off-flavors, and bitterness. Texture of the fruit flesh should be smooth and free of fibers (stringiness). Vascular discoloration (dark streaks) may also affect taste adversely, although this may be a psychological factor.

Oil content affects flavor and texture. Low oil content (less than 10 percent) may result in an insipid, watery taste. Higher oil content (above 12 percent) is associated with richer flavor and a buttery texture. Fruit with very high oil content (above 25 percent) sometimes has an undesirable pasty or "dry" texture, especially when overripe. Hawaii avocado grading standards specify a minimum oil content of 12 percent for avocados sold as Hawaii Fancy (Hawaii Grade AA) or Hawaii No. 1 (Hawaii Grade A). Avocados sold as Hawaii No. 2 (Hawaii Grade B) must have a minimum oil content of at least 10 percent.

Table 2. Characteristics of some avocado cultivars suitable for Hawaii.*

Cultivar	Season of bearing	Race**	Flowering type	Bearing habit	Tree size and form
Greengold	winter–spring	M x G	A	heavy, regular	small–medium
Kahaluu	fall	G x WI	B	light, irregular	tall, upright
Murashige	spring–summer	uncertain	B	heavy	large, upright
Nishikawa	winter	G	B	moderate	medium, spreading
Ohata	summer	G	A	moderate	medium–large
San Miguel	fall–winter	hybrid	A	moderate, regular	medium, spreading
Semil-34	fall–winter	G x WI	A	heavy, regular	medium, spreading
Sharwil	winter–spring	M x G	B	moderate, regular	low, spreading

*Suitability does not imply that the cultivar is adapted to all locations.
**See Table 1.

Fruit appearance

The shape of the fruit, the color, tone, and texture of its skin, and the flesh color all contribute to fruit appearance. Although variation in appearance among varieties can be considered a pleasing aspect of avocado's genetic diversity, a consistent and recognizable appearance is desirable for mass marketing. Certain shapes and colors of avocados have become recognized and preferred, and consumers may resist or reject variants. Hawaii markets offer a much larger number of avocado types than markets on the U.S. mainland. This is due to the large number of local and imported cultivars available, as well as locally grown seedling avocados. The preferences of urban Oahu consumers for avocado types has been surveyed (see CTAHR publication RS 044 [1986], *Characteristics of consumer demand for avocados in Honolulu*). Physical characteristics that can be measured when evaluating avocado fruits include size, shape, color, defects, and percent of skin, flesh, seed, oil, and moisture.

Avocados vary in shape from round to obovate (oval) to pyriform (pear-shaped). Skin color at ripening may be light to dark green, purple, or black. Skin tone varies from dull to glossy, and some varieties have waxy bloom, giving the surface a matte appearance. Skin thickness varies from thin and leathery to thick and brittle. Skin texture varies from smooth to rough and pebbly. Flesh color varies from yellow to greenish-yellow to green. Sometimes the flesh is green near the skin and becomes yellow toward the seed.

Fruit size

For urban retail markets, relatively small fruit size, (from 10 to 18 oz) is usually preferred because cost per fruit is lower, and small fruits are more easily consumed without waste. Fruits larger than 1 lb (0.45 kg) are usually preferred for the hotel and restaurant trade. Hawaii regulations define avocado fruit sizes as small (under 10 oz), medium (10–16 oz), large (16–32 oz), and extra large (over 32 oz).

Seed size and skin qualities

Small seed size is desirable so that a greater proportion of the fruit is edible. Fruits with seeds with more than 28 percent of the total fruit weight are "excessively large seeded" by Hawaii grading standards. When the seed is less than 23 percent of the fruit weight, the fruits are considered "fairly small seeded," and when the seed is less less than 20 percent of the fruit weight, they are "small seeded."

Percentage of skin of avocado fruits can range from less than 10 percent up to about 25 percent. Skin thickness, color, and texture are useful in determining ripeness. Thick, woody skin may protect the fruit from bruising and damage by fruit flies but makes it difficult to

Table 3. Fruit characteristics of some avocado cultivars suitable for Hawaii.*

Cultivar	Weight (oz)	Oil content (%)	Fruit shape	Seed size	Mature skin color**	Skin thick-ness	Flesh color**	Flavor	Peeling	Shelf life
Greengold	8–20	>20	pear	S	g	med	y–g	excellent	good	
Kahaluu	12–20	17–31	obovate	S–M	g	thin	y	excellent	good	good
Murashige	14–30	20	pear	S	g	thick	light y	excellent, mild		fair
Nishikawa	12–18	21–25	pear	M	g	med	y–g	good		poor
Ohata	18–40	13.5	obovate	S	p–bl	med	-	v. good	good	good
San Miguel	12–16	-	obovate	M–L	g	thin	y–g	excellent	good	excellent
Semil–34	14–30	12	pear	S–M	g	med	light y	good	good	excellent
Sharwil	10–20	20–24	pear	S	g	thin	y–g	excellent	good	excellent

*Characteristics may vary with the location in which the cultivar is grown.
**Key to colors: bl = black, g = green, p = purple, y = yellow

determine ripeness by hand pressure. Most thin-skinned avocados peel easily, whereas the flesh must be scooped from the shell of thick-skinned Guatemalan-type varieties. The latter may also have "stone" cells on the interior surface of the skin. These cells can be dislodged, making the flesh gritty, if the flesh is not carefully scooped from the skin.

Ripening and storage

Avocado fruits often exhibit external changes during the ripening process or upon maturation. Skin color or tone may change. In some cultivars, fruit skin tone changes from glossy to dull as the fruit matures. Fruits of some cultivars may be "stored" on the tree for several weeks or even months after maturity. Mature fruit of a good commercial cultivar should have a postharvest life of at least two weeks to allow time for marketing.

Fruits of some cultivars are prone to postharvest decay. Some may have higher tolerance of refrigeration after ripening than others. These are important factors in evaluating new selections.

Selecting an avocado cultivar for the home garden

Avocados are a favorite home garden fruit in Hawaii. Homeowners selecting an avocado cultivar or cultivars for their yard will not have the same criteria for production or fruit quality characteristics as would commercial growers. In fact, individuals may prefer certain cultivars that would not be recommendable for commercial purposes.

People planting avocado trees are advised to take an experimental approach by planting several cultivars, if possible, with the intention of later removing the ones that are less productive or have poorer fruit quality. Use grafted plants of cultivars that have been tried in and recommended for Hawaii's conditions and, preferably, for locations similar to yours. Plant cultivars of both pollination types if they are to be grown in isolation from other avocado trees. For general advice on growing avocado, see the CTAHR publication AVO-3(A), *Avocado*.

Availability of avocado cultivars

Mention of a cultivar name in this publication is not a guarantee of its availability. Cultivars represented by only a few trees may have become "extinct." Trees may be lost to disease or age, removed for development or planting of other trees, or discarded from research collections.

Commercial availability of avocado cultivars is subject to market demand. Nurseries and commercial propagators may carry only a few cultivars that they happen to know about. They also may offer cultivars that are their own favorites but that are not recommended in this publication.

This information on avocado cultivars is based primarily on the observations of Richard A. Hamilton, emeritus professor of horticulture, as interpreted by Dale Evans, CTAHR Publications and Information Office. Work on this publication was initiated under a grant from the Governor's Agriculture Coordinating Committee to C. L. Chia, Dept. of Horticulture. Examples of cultivar differences due to elevation are the observations of Edward T. Fukunaga, former Extension Agent, UH Cooperative Extension Service.

Table 4. Avocado cultivars that have been tested in Hawaii.*

Suitable for home gardens or (c) commercial production

Greengold [c]
Haley
Kahaluu
Murashige [c]
Nishikawa
Ohata
San Miguel
Semil-34 [c]
Sharwil [c]

Acceptable for home gardens but not recommended as commercial cultivars

Adachi
Al Boyce
Alpha
Azul
Basalua (Gallito)
Beardslee
Benick
Butler
Case
CES 526
Chang
Coban
Dailey #1
Dupuis #2
Elsie
Frowe
Fuerte
Fujikawa
Gripina 5
Guatemala
Hashimoto R1T15
Hashimoto
Hass
Hayes
Healani
Hulumanu
Ilialu
Jan Boyce
Kaguah
Kampong
Kashlan
Manik
Masutomi
Medeiros
Nutmeg
Ota
Pankay
Panchoy
Josefina
Ruehle
Rodrigues
Semil 43
Seyde
Simmonds
Tumin
Wahiawa
Wainaku
Wurtz

Tested and not likely to be recommended

Anaheim
Arturo
Ashikawa
Avila
Aztec
Bon
Booth 8
Booth 7
Brogden
Butler
Celaya
Cho
Chris Kelly
Chrones
Colinred B
Commonfort 48
Duke
Dr. Lyon
DW1 Bank
Esbank
Esparta
Garcia
Grip 12
Gripina 2
Hansen
Irwin
Itzamna
Jalna
Jeanette
Kaneko
Kanola
Kosel
Lehua
Leucadia
Linda
Lula
Lycett
Mac Arthur
Masami
McDonald
Mexicola
Monge
Murietta
Nabal
Nena
Nowels
Obregon
Ozaki
Pollock
Reinecke
Rey tacambaro
Rincon
Sato
Serpa
Sexton
St. Claire
Tanabe
Tanaka
Tanaka (Haina)
Teague
Thevenin
Tolbe
Towse
Tsutsumi
Vargas
Winter Mexican
Wong
Yamagata
Zutano

*Suitability is based on cultivar characteristics observed in one or more locations and does not guarantee that the cultivar is adapted to all locations. Evaluations are based primarily on the observations of Dr. Richard A. Hamilton. Preferences vary among individuals and some may find a cultivar usable despite the fact that many horticulturists would reject it.